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(54) Abstract Title
Modifying image data

(57) An image data modifying system has devices for image storage, display, processing and manual control. The storage device is arranged to store many modifying textures in the form of stamps having fewer pixels than a full image frame. The processing device constructs a new texture stamp by scaling a first stamping texture, expanding a second stamping texture without scaling and combining the scaled texture with the expanded texture. In this way, the effect of scaling artefacts is significantly reduced.

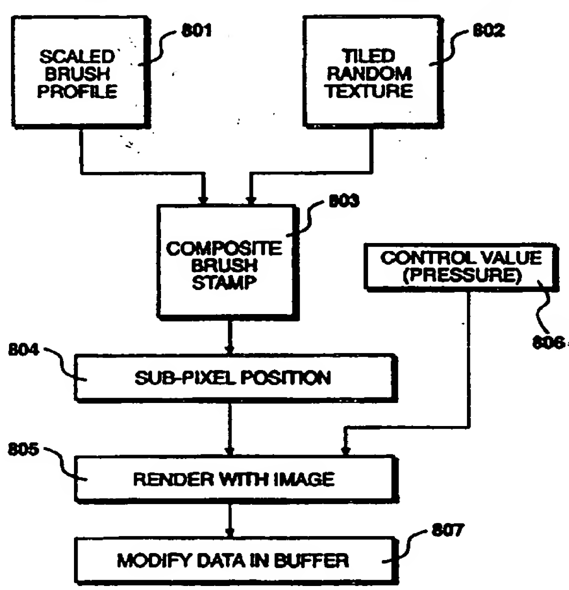

Figure 8

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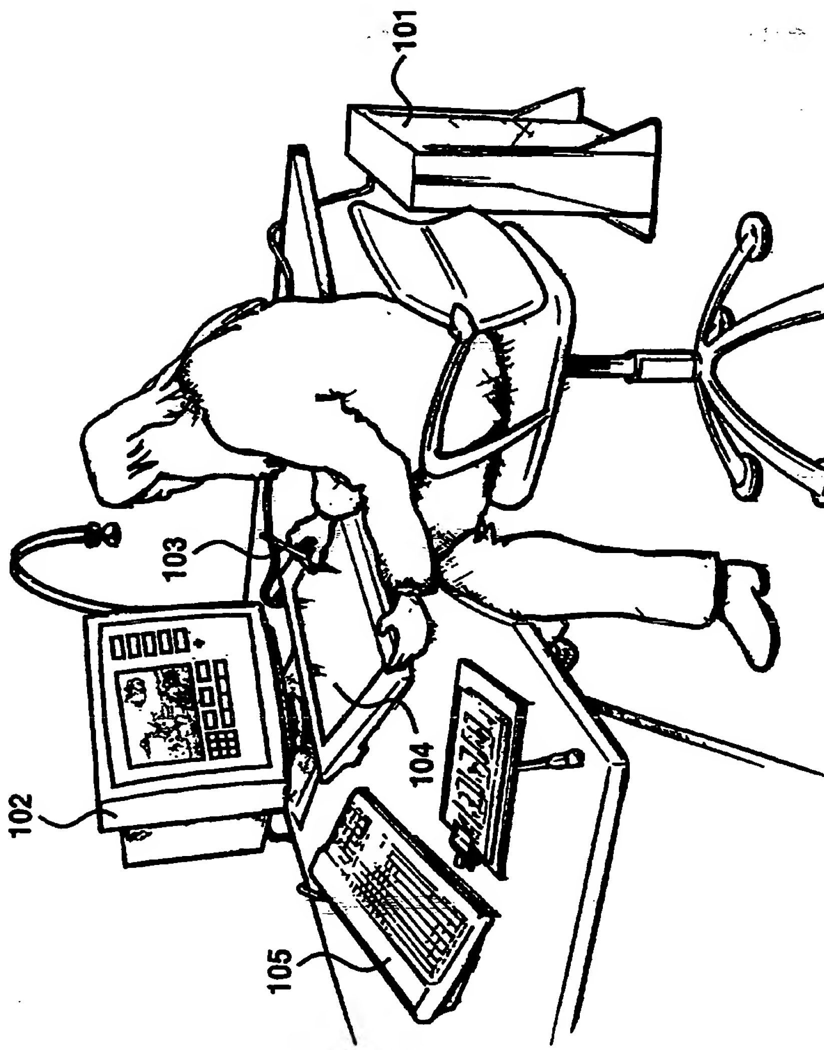


Figure 1

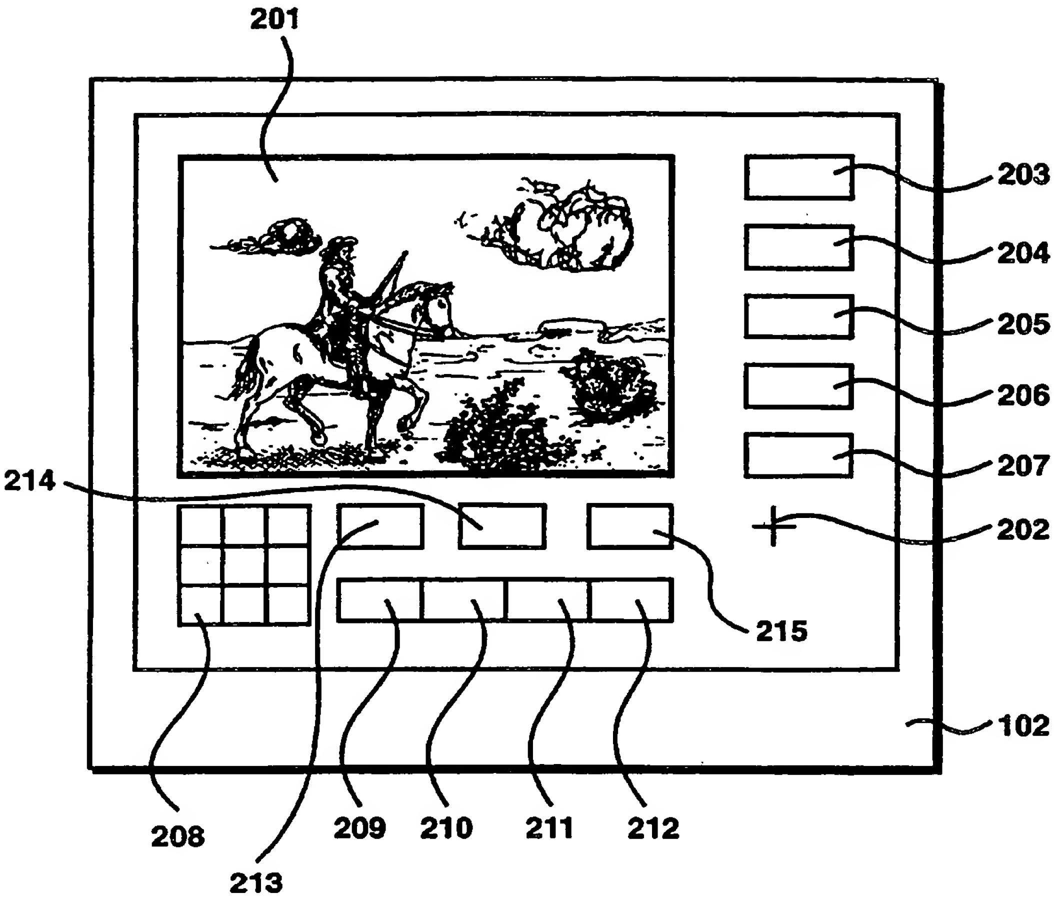


Figure 2

TEXTURE				313
RATE	309	310	311	312
SIZE	305	306	307	308
INTENSITY	301	302	303	304
	PRESSURE	VARY IN X	VARY IN Y	CONSTANT

Figure 3

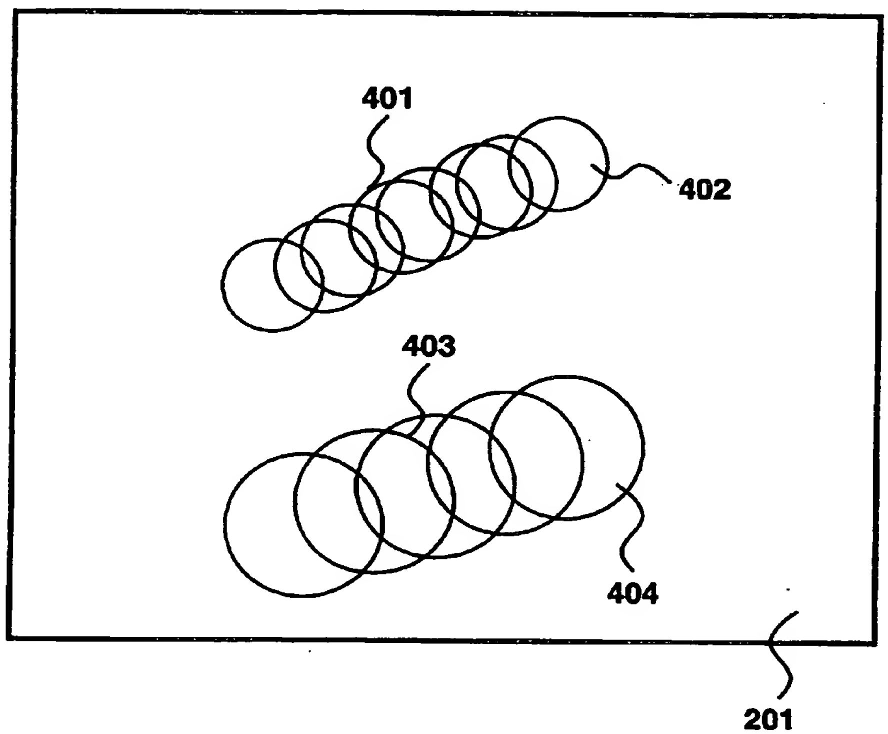
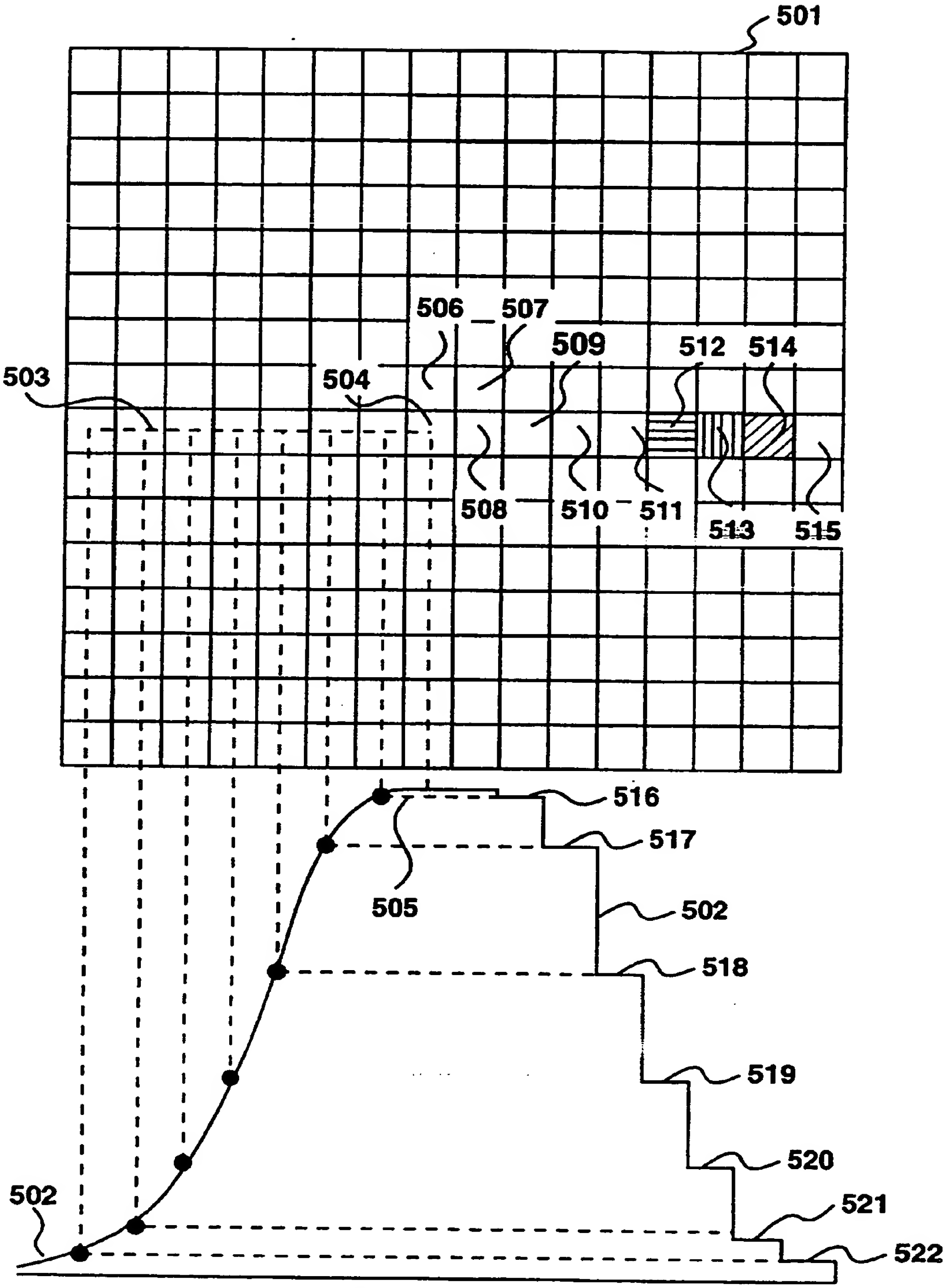


Figure 4


501
503
504
505
506
507
508
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502
518
519
520
521
522
502

Figure 5

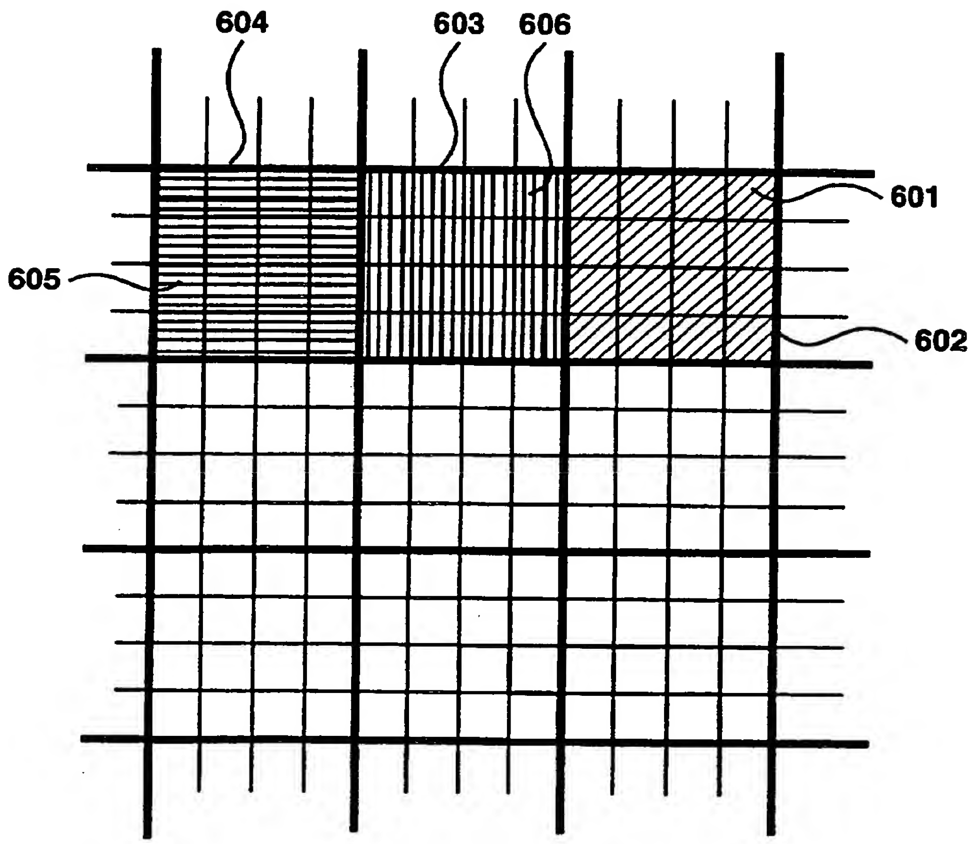

Figure 6

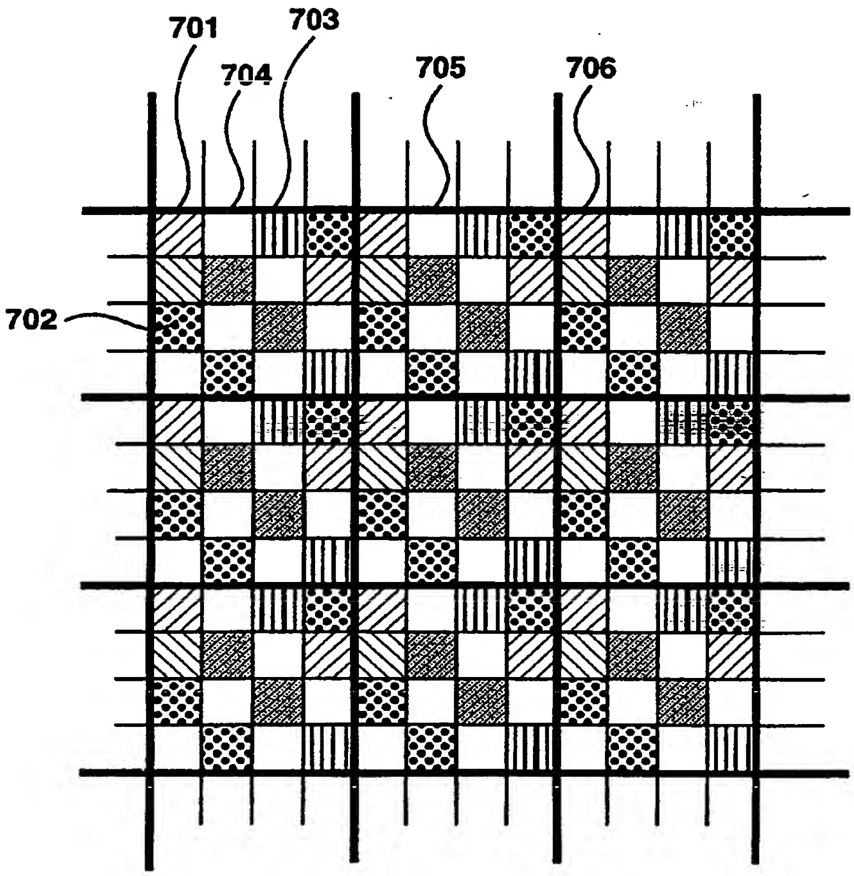

Figure 7

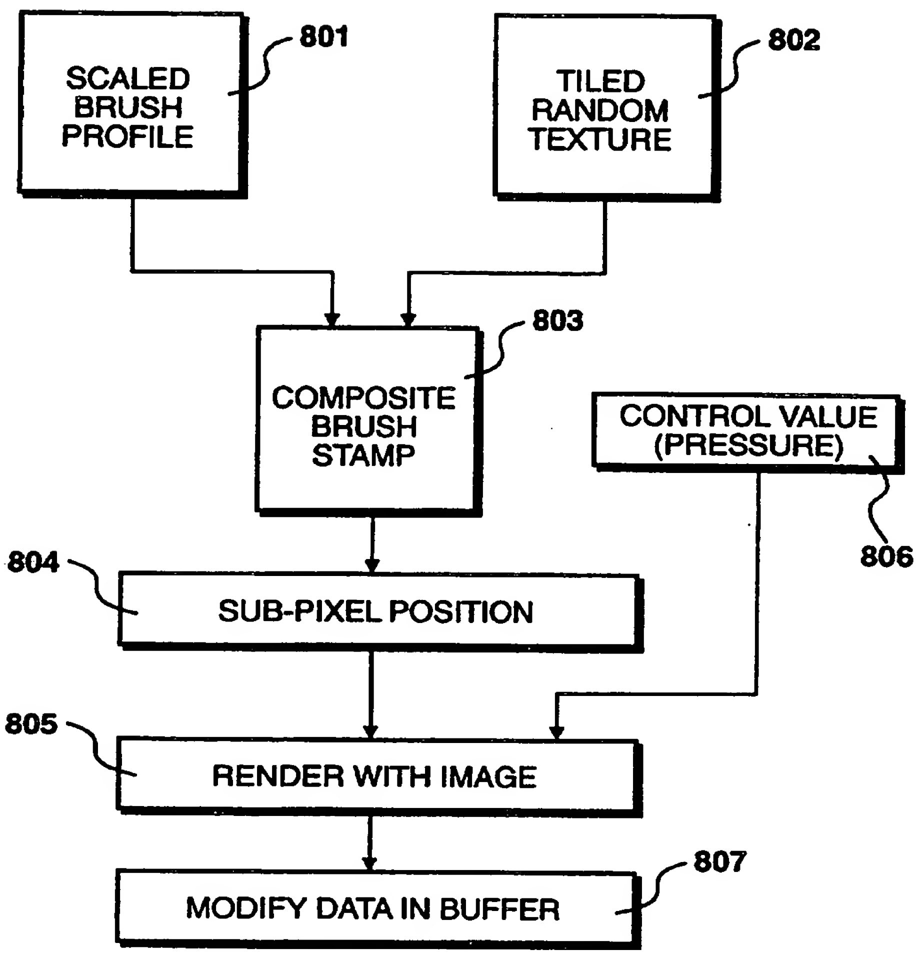
SCALED BRUSH PROFILE
801
TILED RANDOM TEXTURE
802
COMPOSITE BRUSH STAMP
803
CONTROL VALUE (PRESSURE)
806
804
SUB-PIXEL POSITION
805
RENDER WITH IMAGE
MODIFY DATA IN BUFFER
807

Figure 8

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Modifying Image Data

The present invention relates to image data modifying apparatus, comprising image storage means, image display means, processing means and a manually controllable input means. In addition, the present invention relates to a method of modifying image data in which pixel values in an image are modified in response to manual operation of an input device.

The manual modification of image data within a data processing environment or video editing environment etc. is commonly referred to as "painting". While no physical paint is actually involved in this process, the operation performed by an artist, using a mouse, stylus or similar manually operable device, is similar to the action of applying a brush to a canvas and measures are often adopted within the environment to copy the response of brushes and similar graphical tools.

Painting processes are often implemented by performing a sequence of stamping operations in which a region of pixels lying underneath the notional footprint of a stamp are modified in response to values stored within a stamp patch, in addition to other control values which may be derived from stylus pressure etc. It is also known to store a plurality of stamp patches, each representing a different increment of sub-pixel brush movement, such that the effect of a natural brush stroke with a definition in excess of pixel resolution may be accurately simulated.

As the definition of images increases, such as when modifying high definition video or when modifying images derived from cinematographic film, the number of pixels covered within a brush stamp will also increase proportionally and, in systems where a particular profile is recorded for each possible size, a significant number of brush profiles will need to be made available; although it is unlikely that all of these would actually be required for a particular job.

In order to overcome this problem and to avoid the need for storing a very large number of brush profiles, it is known to store an example of the brush profile representing a particular shape and to produce the range of sizes by scaling the brush profile. Furthermore, it is also known to manipulate brush profiles in the form of textures which may then be rendered into an existing frame buffer image at sub-pixel resolution. Thus, in this way, it is possible to store a single brush profile which may be used to produce high definition sub-pixel stamping in addition to producing a plurality of brush sizes, thereby drastically reducing the number of brush profiles which need to be stored. Thus, in a typical environment, it becomes only necessary to store a new brush texture if a differently shaped brush profile is required. Thus, brush profiles may be provided for simulating the effects of air brushes, stipple brushes, chalk, paint brushes and pencils etc. and the same data may be scaled and positioned at sub-pixel resolution so as to provide smooth anti-aliased stamping.

A problem with this approach is that as a brush stamp is scaled, many pixel values within the brush stamp will be given similar intensity values. As a brush of this type is used repeatedly, unwanted artefacts between brush values may become visible and possibly displayed in the form of a series of rings. Furthermore, the availability of processing resource for mitigating the effect of these rings is limited, given that the pixel processing is required in real time, in response to manual indications made by an operator.

According to a first aspect of the present invention, there is provided an image data modifying apparatus comprising image storage means, image display means, processing means and a manually controllable input means, wherein said storage means is arranged to store a plurality of modifying textures in the form of stamps having fewer pixels than a full image frame; and said processing means is configured to construct new texture stamps by scaling a first stamping texture, expanding a second stamping texture without scaling and combining said scaled and said expanded textures.

In a preferred embodiment, the first stamping texture represents a brush profile and said storage means may be configured to store a plurality of brush profiles. Preferably, the second stamping texture represents random noise and said random noise may have a relatively low amplitude.

According to a second aspect of the present invention, there is provided a method of modifying image data, in which pixel values in an image are modified in response to manual operation of an input device, comprising steps of storing a first stamping texture, storing a second stamping texture and producing a new stamping texture by scaling said first stamping texture while expanding said second stamping texture without scaling.

Preferably, a new texture is rendered into an image at sub-pixel definition.

The invention will now be described by way of example only, with reference to the accompanying figures, in which:

Figure 1 illustrates a video artist performing a painting operation upon a video frame, including a manually operable device and a visual display unit;

Figure 2 details a main screen shown on the visual display unit, including buttons for selecting modes of operation, including a set-up mode;

Figure 3 details an image displayed on the visual display unit in response to selecting the set-up mode identified in *Figure 2*;

Figure 4 illustrates painting stamps being applied to the displayed canvas shown in *Figure 2*;

Figure 5 illustrates a pixel texture map making up a relatively small stamp of the type shown in *Figure 4*;

Figure 6 shows how the relatively large stamp shown in *Figure 4* is generated from the smaller texture map illustrated in *Figure 5*;

Figure 7 illustrates a noise texture map formed by tiling smaller texture maps; and

Figure 8 illustrates how the scaled bush profile and the tiled random texture are combined in a painting operation performed by the apparatus illustrated in *Figure 1.*

A facility for performing "painting" operations upon digital image data is illustrated in *Figure 1.* A processing system **101** is configured to store digital representations of image frames such that individual frame data may be displayed to an operator by means of a visual display unit **102.** In response to this displayed image, an operator provides input data to the processing system **101** via a manually operable device, such as a stylus **103** arranged to co-operate with a touch tablet **104.** In addition, the operator is also provided with a conventional keyboard **105.**

A typical image displayed on the VDU **102** is detailed in *Figure* 2. The display includes a canvas area **201** in which a visual image is created or an existing image is modified. Movement of stylus **103** is detected by system **101** which in turn displays a cursor **202** arranged to map movements of the stylus **103** over the touch tablet **104.** Cursor **202** may be moved into the canvas area **201** while performing "painting" operations. In addition, the cursor **202** may also be placed over soft buttons which are activated by placing the stylus **103** into pressure. In this way, particular types of operation may be effected by selecting soft buttons **203, 204, 205, 206** and **207**. Thus conventional painting operations may be selected by these buttons, in which a new colour is applied to the image or, alternatively, an operation may be selected in which a control plane, or matte, is modified so as to change the way in which two image frames are blended.

The image screen displayed on monitor **101** also includes a palette area **208** allowing particular colours to be selected, along with buttons **209, 210, 211** and **212** allowing particular brush profiles to be selected. Thus, button **209** may select a sharp edged pencil, button **210** may select a softer edged paintbrush, button **211** may select a stippled or textured brush and button **210** may select a very smooth edged airbrush.

Operational parameters of the system may be modified in response to activating system buttons, including buttons **213**, **214** and **215**. In this embodiment, the selection of button **215** allows the nature of the painting operation to be modified and results in the screen shown in *Figure 2* being replaced by a screen of the type shown in *Figure 3*.

The screen shown in *Figure 3* again includes a plurality of buttons **301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312** and **313**. During operation of the stylus **103** it is possible to vary the pressure applied to the stylus, modify the position of the stylus in the x direction and modify the position of the stylus in the y direction. These variables are expressed horizontally allowing relevant selections to be made from the matrix of buttons **301** to **313**. These input variables may in turn adjust the intensity of the stamping, the size of the stamping, the rate at which stamping occurs and the texture of the stamping.

In this way, when button **301** is activated, resulting in the way in which the button is represented being changed, the intensity of the brush stamp will vary in response to variations in applied pressure. These soft buttons are configured as toggles such that selecting button **301** again will result in the button being switched off such that intensity will not vary with pressure.

Similarly, activation of button **302** will result in the intensity varying with respect to movement in the x direction and the selection of button **303** will result in variations occurring with respect to y directional movement. The selection of button **304** effectively cancels the operation of buttons **301** to **303** and ensures that the intensity of modifications applied to the existing image remains constant, irrespective of input modifications.

A similar situation is provided for adjusting the size of brush stamps. Thus, the activation of button **305** allows size to be modified with respect to pen pressure, the activation of button **306** allows size to be modified with respect to the x position, the activation of button **307** allows size to vary with respect to the y position and the activation of button **308** ensures that size

remains constant irrespective of these variations.

Thirdly, the rate at which stamps are applied to the image may be modified with respect to pressure by the activation of button **309**, with variations in the x and y direction being controlled by the activation of buttons **310** and **311**. Again, the activation of button **312** ensures that the rate of stamp application remains constant irrespective of input variables.

The application of texture to brush stamps introduces noise in accordance with the present invention. When button **313** is activated, noise will be introduced into the brush stamping from a tiled texture map, thereby mitigating the undesirable effects due to the scaling of brush profiles. Button **313** is configured as a toggle and therefore once activated may be de-activated by a similar selection.

Canvas **201** is illustrated in *Figure 4*, in which a first stroke **401** has been created by a plurality of textured stamps **402**. The size of these stamps may be increased to produce a brush stamp of substantially similar profile but with a larger area of application. Thus, such a process may be implemented in order to create stroke **403** constructed from brush stamps **404** scaled up from the brush stamps used to create stroke **401**.

Each brush stamp is derived as a texture which is rendered into a frame buffer at sub-pixel definition in response to the position of the stylus **103** upon the touch tablet **104**. Brush profiles are retained in memory in the form of a pixel patch which may consist of a square of 16 x 16 pixels, 32 x 32 pixels, 64 x 64 pixels, or 128 x 128 pixels, etc. depending upon the definition of images being processed. A patch **501** of this type is illustrated in *Figure 5*, consisting of an array of 16 x 16 pixel values. In this embodiment, when larger brushes are required of substantially similar profile, pixel patch **501** is expanded to provide the number of pixels required.

The patch **501** represents the two dimensional area of coverage in terms of pixel locations and the profile of the brush stamp is defined by the intensity values of the pixels, which may be represented as a surface

extending vertically away from the plane. Such a surface is illustrated as a projection **502**, which provides a basis for calculating actual pixel values contained within the patch. Thus, although the profile may be visualised as a smooth surface, given the digitised nature of the patch, the values actually contained within the patch have discrete values therefore the actual profile may be considered as that represented at **502**.

Profile **502** represents the profile of relevant pixels laying along line **503**. The pixel at location **504** is set to its maximum intensity identified as **505**. A similar intensity is allocated to pixels **506**, **507** and **508**. As pixel locations extend radially away from the centre, their intensities decrease. Thus, pixel locations **509**, **510**, **511**, **512**, **513**, **514** and **515** have intensity values represented at **516**, **517**, **518**, **519**, **520**, **521** and **522** respectively.

Other profile shapes are stored representing different types of brushes, each with a pixel patch of 16 x 16 pixels. Generating a brush stamp which is four times larger in both the x and y dimensions, the 16 pixel x 16 pixel patch is scaled up to a 64 pixel x 64 pixel patch. Each pixel patch contains fewer pixels than a full image frame and is arranged to be scaled to provide the size of patch required. Thus, a value from each pixel in the original 16 x 16 profile will be copied to 4 x 4 pixels in the scaled 64 x 64 pixel patch.

In addition to storing a patch for each brush profile, a further patch is stored representing substantially random noise. A new texture stamp is created for being rendered within the image frame. The first stamping texture, representing the profile, is scaled which may result in the creation of undesirable artefacts. However, the second stamping texture, representing the substantially random noise, is expanded without scaling, preferably by a process of tiling. The scaled profile is then combined with the tiled noise to produce the new texture map in a way such that the tiled noise mitigates the effects of the undesirable artefacts introduced by the scaling of the profile.

Part of a scaled brush profile is illustrated in *Figure 6*. Each small square, such as square **601**, represents an individual pixel of the scaled texture. Each 4 pixel x 4 pixel square, identified by thickened boundaries **602**, represents the regions scaled from a single pixel contained within the original profile. Thus, in this example, it may be assumed that region **602** is obtained from pixel position **514**, region **603** is obtained from region **513** and region **604** is obtained from pixel **512**. Thus, all pixels **605** within regions **604** will have an intensity of **519**. All pixels **606** within region **603** will have an intensity of **520** and all pixels **601** within regions **602** will have an intensity of **521**.

The tiling of noise is illustrated in *Figure 7*. In this example, it is assumed that the base tile consists of 4 pixels x 4 pixels although in practice the base tile would tend to contain significantly more pixels. Each pixel **701** within a tile **702** has a substantially random value although the amplitude of these values will tend to be restrained within a relatively low range, such that the magnitude of the noise data is relatively small compared to the magnitude of the brush profile data. In this way, the noise may be considered as introducing a level of "dithering" to the brush profile and is not intended to substantially modify the brush profile.

Pixel **701** has a particular noise value with pixel **702** having a randomly different value and again a different value is given to pixel **703** and so on. On the next tile, pixels at similar positions have similar values, introduced by effectively reproducing the base tile in a tiling operation. Thus, pixel **705**, of tile **706** has the same value as pixel location **701**.

Thus, it can be seen that the way in which brush profiles are expanded, as a scaling operation illustrated in *Figure 6*, differs from the way in which the noise is expanded, as a tiling operation, as illustrated in *Figure 7*. In this way, distortion artefacts introduced by each individual operation of tiling and the scaling of profiles do not mutually reinforce each other when the two expanded textures are combined, so that the combining process reduces unwanted artefacts arising from profile scaling.

The overall procedure is illustrated in *Figure 8*. The process shows a situation in which a brush stamp is required which is larger than the stored profiles. At process **801** a brush profile, of the type shown in *Figure 5*, is scaled in the way described with reference to *Figure 6*. Process 802 produces an expanded tiled random texture, invoking a process substantially similar to that described with respect to *Figure 7*.

At process **803** the scaled brush texture from **801** and the tiled random texture from **802** are combined to produce a composite brush stamp.

The position of the brush stamp to sub-pixel definition is identified as **804** and the brush stamp is rendered with an image at **805** under the control of a control value derived from **806**, usually derived from stylus pressure.

After rendering the new image at step **805** to determine new pixel values and filtering the image to take account of sub-pixel definition, the two images are combined as a modification process at step **806**.

Claims

1. Image data modifying apparatus, comprising image storage means, image display means, processing means and a manually controllable input means, wherein

said storage means is arranged to store a plurality of modifying textures in the form of stamps having fewer pixels than a full image frame; and

said processing means is configured to construct a new texture stamp by scaling a first stamping texture, expanding a second stamping texture without scaling and combining said scaled and said expanded textures.

2. Apparatus according to claim 1, wherein said first stamping texture represents the brush profile.

3. Apparatus according to claim 2, wherein said storage means is configured to store a plurality of brush profiles.

4. Apparatus according to any of claims 1 to 3, wherein said second stamping texture represents random noise.

5. Apparatus according to claim 4, wherein said random noise has a relatively low amplitude.

6. Apparatus according to any of claims 1to 5, wherein a new texture is rendered into an image at sub-pixel definition.

7. A method of modifying image data, in which pixel values in an image are modified in response to manual operation of an input device, comprising steps of storing a first stamping texture, storing a second

stamping texture and producing a new stamping texture by scaling said first stamping texture while expanding said second said second texture without scaling.

8. A method according to claim 7, wherein said first stamping texture represents a brush profile.

9. A method according to claim 8, wherein a plurality of brush profiles are stored.

10. A method according to claim 7, wherein said second stamping texture represents substantially random noise.

11. A method according to claim 10, wherein said random noise has a relatively low amplitude.

12. A method according to claim 7, wherein a new texture is rendered into an image at sub-pixel definition.

13. A computer-readable medium having computer-readable instructions executable by a computer such that said computer performs the steps of:

storing a first stamping texture in a first data field;

storing a second stamping texture in a second data field; and

modifying image data by producing an output stamping texture in response to scaling said first stamping texture while expanding said second stamping texture without scaling.

14. A computer-readable medium having computer-executable instructions according to claim 13, wherein said first stamping texture

represents a brush profile.

15. A computer-readable medium having computer-executable instructions according to claim **14**, wherein a plurality of brush profiles are stored.

16. A computer-readable medium having computer-executable instructions according to claim **13**, wherein said second stamping texture represents substantially random noise.

17. A computer-readable medium having computer-executable instructions according to claim **16**, ~~wherein said random noise has a relatively~~ low amplitude.

18. A computer-readable medium having computer-executable instructions according to claim **13**, wherein a new texture is rendered into an image at sub-pixel definition.

19. A computer-readable storage system having a plurality of data fields stored on said medium and representing a data structure, comprising

a first data field representing a first stamping texture; and

a second data field representing a second stamping texture, such that, in response to image data modifying instructions an output stamping texture is produced by scaling said first ~~texture and expanding said second texture~~ without scaling.

20. A storage system having a plurality of data fields according to claim **19**, wherein said first stamping texture represents a brush profile.

21. Image data modifying apparatus, substantially as herein described with reference to the accompanying drawings.

22. A method of modifying image data, substantially as herein described with reference to the accompanying drawings.